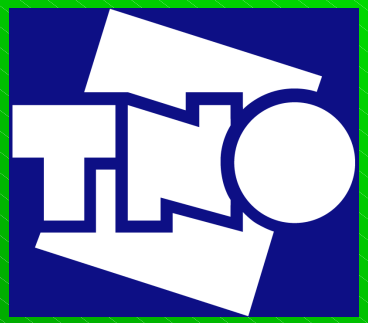

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NATO RTO/SET-069/RTG37

Robust Acquisition of Relocatable Targets using MMW Sensors

NATO School Oberammergau, May 10-12, 2005

SET-096 / MATRIX 2005

FGAN

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Status of the Technical Team

SET-069 declared itself a
Limited Participation Technical Team **(LPTT)**,
the participating nations being
US, CA, UK, GE, FR and NL.

All results of MATRIX 2005 will consequently be confined to these 6 nations

History of SET-069

- RSG.8 „Propagation and Target/Background Signatures at Millimetre Wavelengths“ Land Subgroup (1980‘s)
- RSG.20 „Military Applications of Millimeter Wave Imaging“ (1992-1998)
- TG.14 „Advanced mmw Techniques for Ground Target Acquisition“ (1999-2002)
- SET-069 (2003-2005)
- ? (2006 - ?)

Former workshops

- May 1990, Eglin AFB, „MMW Data Reproducibility, Comparability and Blending
- Nov.1992, Hanscom AFB, „Military Applications of Millimetre Wave Imaging“
- Sept.1998, Panama City, FL, „Military Applications of Millimetre Wave Imaging“

Charter of SET-069

In continuation of the work done by SET-TG.14, the present group aims at an understanding of the sensitivity of the active mmw signature of relocatable targets to the wide variety of engagement conditions.

SET-069 is working with other expert groups such as Industry, Government agencies and Universities to expand the body of knowledge. Presentations are invited to each meeting.

Program of Work 2003-2005

The aim is to identify and analyse features of the mmw active/passive target signature that are robust to:

- camouflage & passive countermeasures
- target-target variability
- environmental conditions
- sensor issues (DBS/SAR/RAR)

A two-fold approach is pursued:

- an active mmw database has been constructed (air-borne and tower/turntable)
- RCS modelling is employed to improve signature understanding

Program of Work 2003-2005, cont'd

- study the differences between discrimination/classification performance predicted on the basis of ISAR data and that directly observed in representative airborne environments.
- improve robustness and performance through the use of *a priori* information that may originate from other sensors present during the mission planning (e.g. target orientation or contextual information)
- improve the performance of the compact sensor on either a weapon, UAV or ground based target acquisition radar by the fusion of imagery produced by MMW and EO sensors.
- Evaluate the benefits of this approach against MMW sensors alone.

Tasks for MATRIX 2005

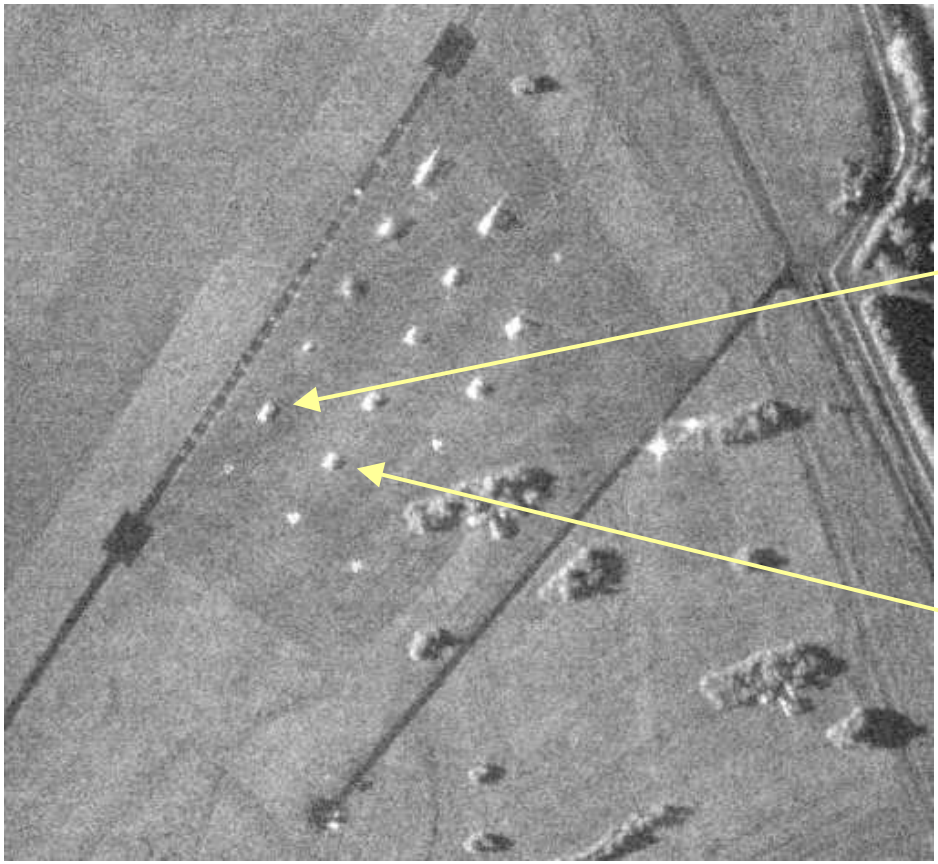
- The exploitation of ISAR data for target classification: is ISAR(TT) a valid approach (as opposed to airborne measurements) for training of ATR algorithms?
- Comparison between tower/turntable and airborne (circle flights, Spot SAR, SAR) target measurements
- The recognition & identification of ground targets within the air-borne data-sets
- Evaluation of the effect of camouflage or decoys on the performance of high quality robust ATR algorithms.
- RCS modeling incl. mmw-specific issues
- Theoretical thoughts on the duality between intra-class stability (robustness) and inter-class separability.

Data Pool, examples

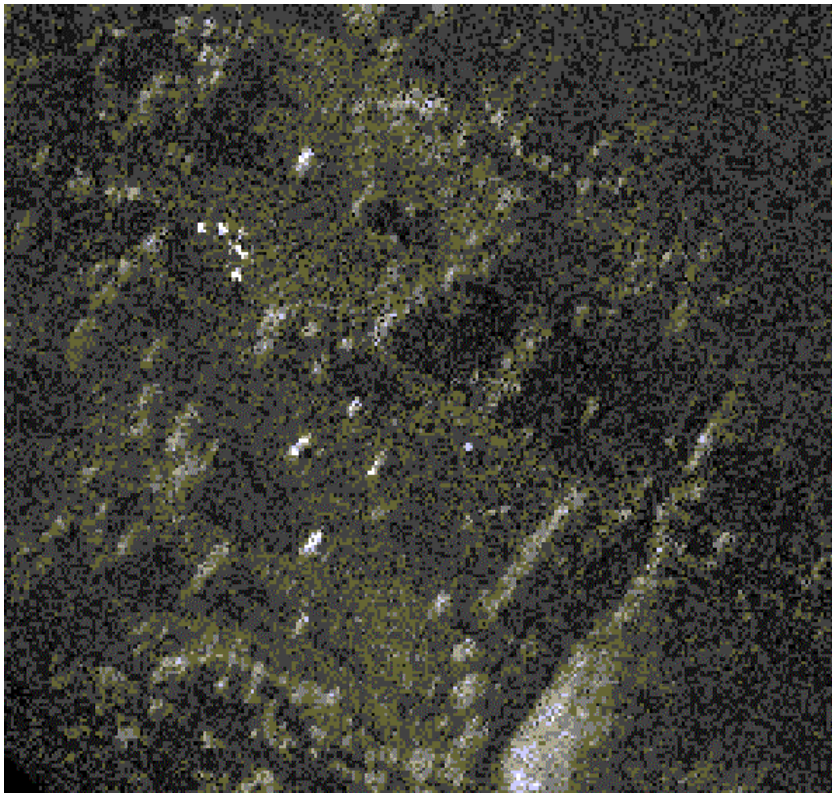
Overview of the data pool

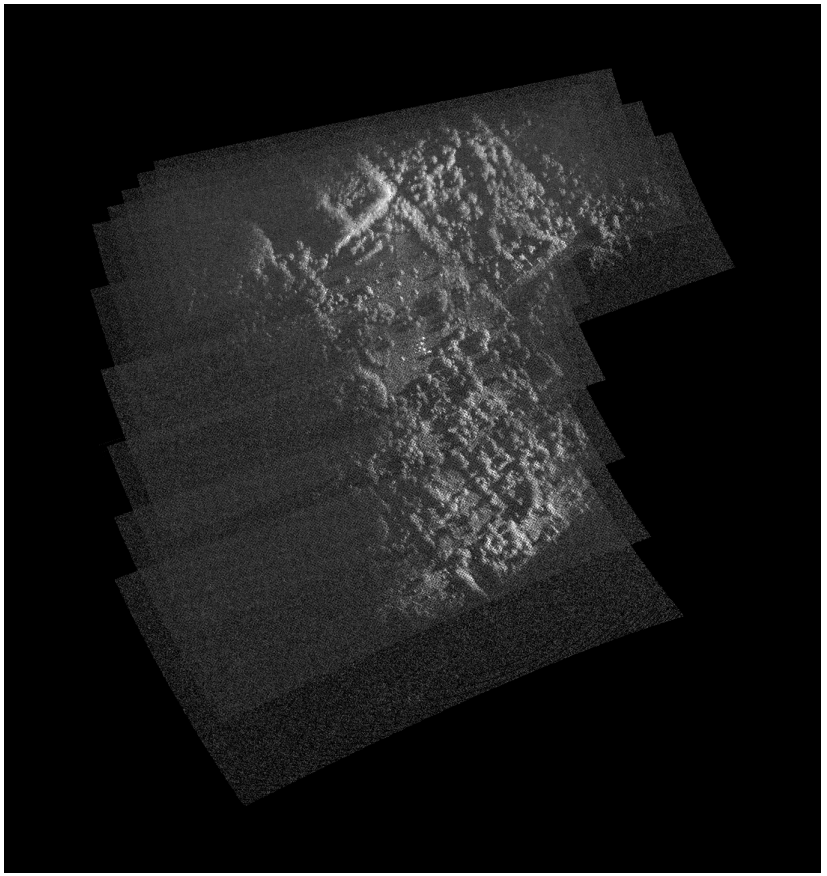
- SAR (20°) and DBS (10°) airborne scenes with rural or urban background
- Tower/turntable data of targets (T72, ZSU, BMP, T62 and SA-8) which are present in airborne scenarios
- Facet models of ZSU (80,000 or 600,000 facets) and trihedron.

SAR data S1, Germany, June 2002



DERA: DBS data from S2, United Kingdom, Oct.2000

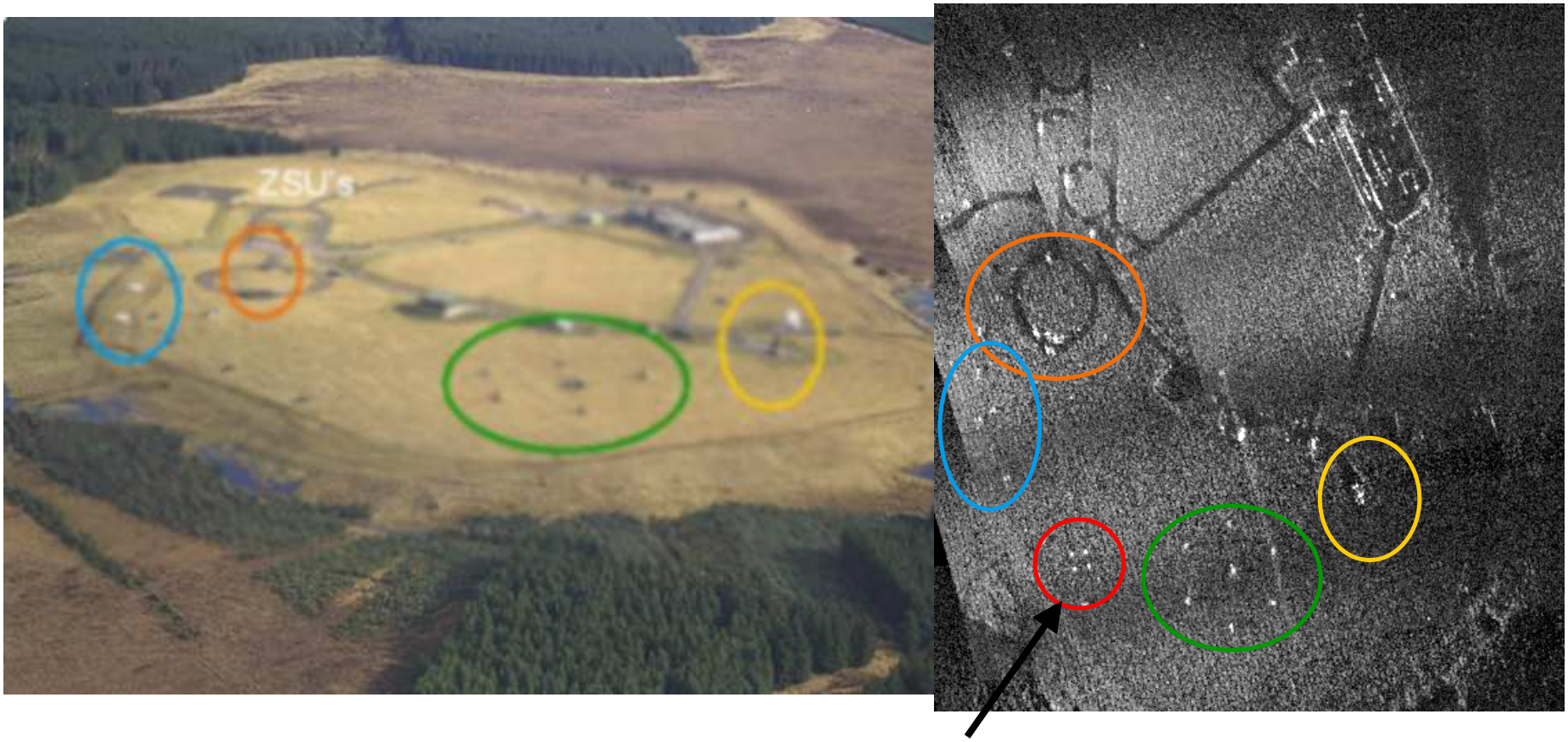




T72 Main battle tank (MBT)
T62 MBT
ZSU 23-4 Air defence unit (ADU)

Area S3 (rural)

1m x 1m ground map Search Mode



4m x 4m cal array

RCS Modeling

Radar Signature Prediction

- Tilted Trihedral Corner (~ 140 cm x 60 cm x 20 cm)
- Polished aluminum full-scale canonical target
- Tilted Corner with Lossy Dielectric on the Bottom Plate
- Comparison with RCS simulation, published by ARL (9, 10, 34, 94 GHz)

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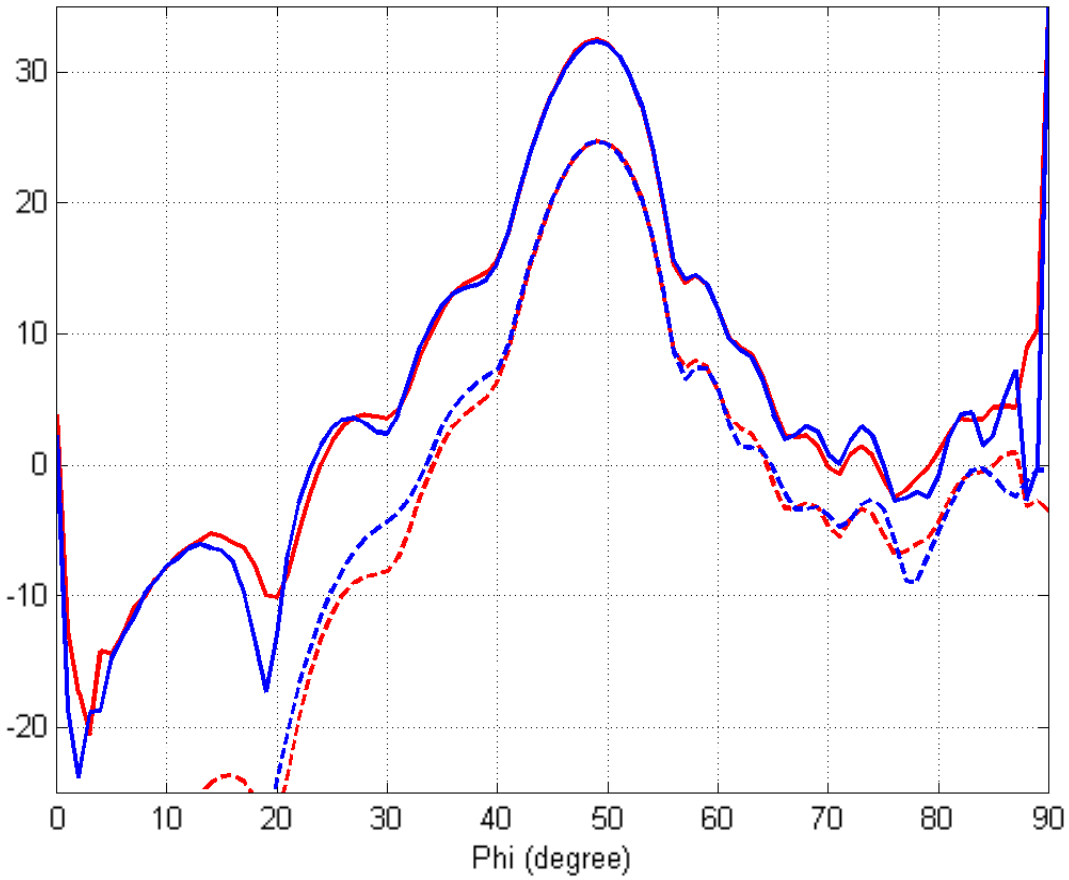
K_a-Band RCS (in dBsm) with lossy dielectric on bottom plate



34 GHz

XPATCH

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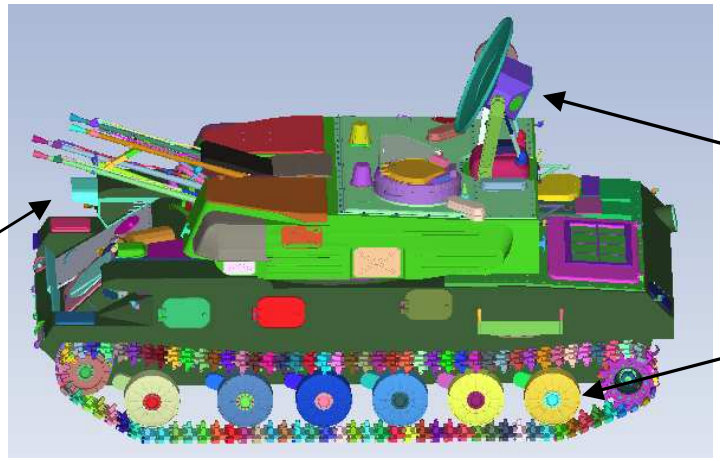
ZSU-23-4 Facet Description

- The public release, low-fidelity model (~633k facets) approximates the radar test vehicle (413 *k*in^2 total facet surface area).
  - Created by the U.S. Army Virtual Target Center
  - Uses only public domain sources/photographs
- The model was modified by removing features not mounted on the range test vehicle and retaining only metallic components which are modeled as PEC.
  - ZSU-23-4 *antenna* positioned at ~30° to match test vehicle articulation
  - ZSU-23-4 *guns* positioned at 16° to match test vehicle articulation
- Ground plane can be added, 10% grade to represent range foreground



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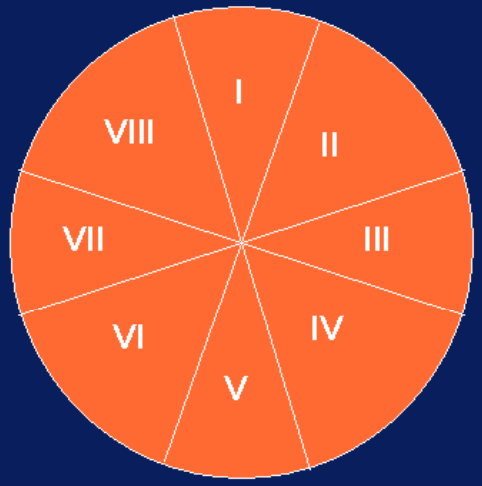
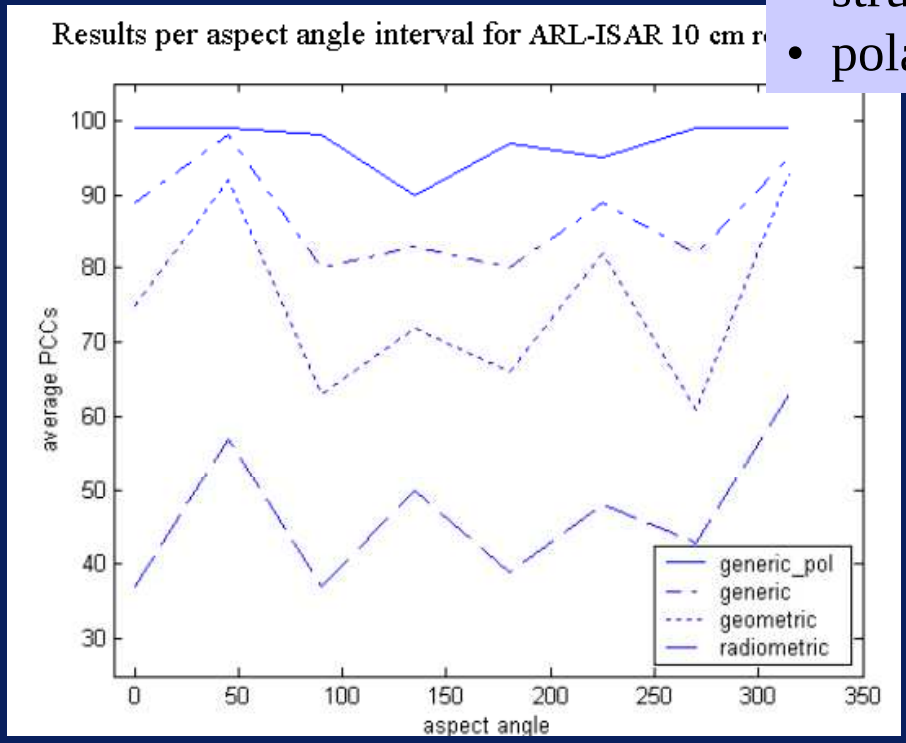
Robust Features

Aspect angle intervals



I	345 - 15 deg
II	15 - 75 deg
III	75 - 105 deg
IV	105 - 165 deg
V	165 - 195 deg
VI	195 - 255 deg
VII	255 - 285 deg
VIII	285 - 345 deg



Feature types:
- geometric
- statistical
- radiometric
- structural
- polarimetric

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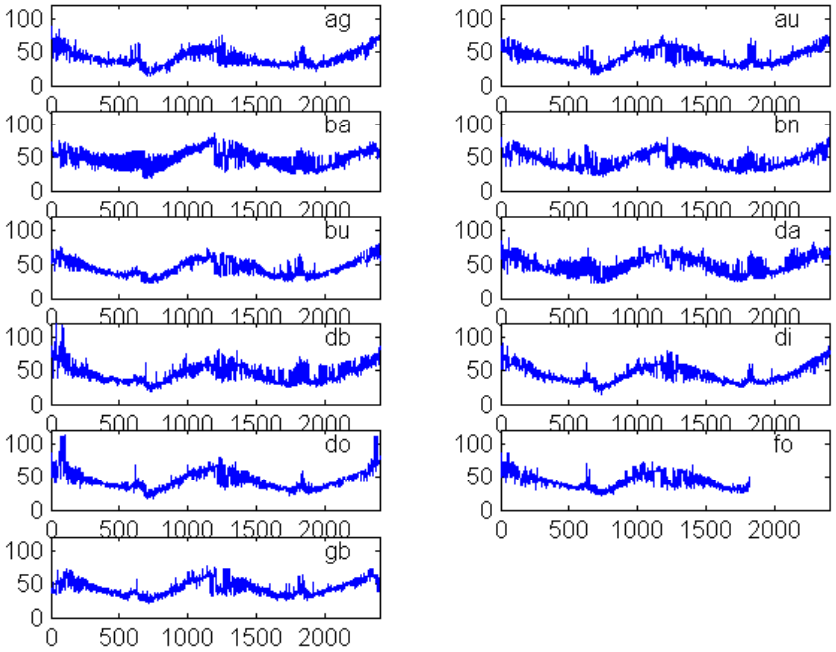
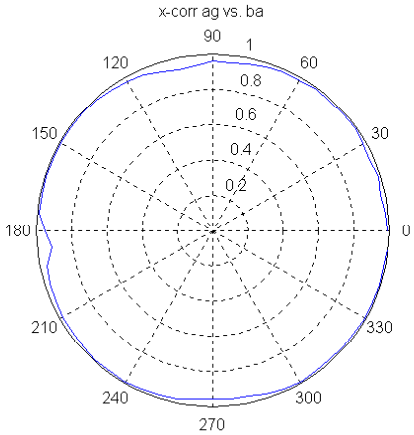
Robustness of length estimation



Robustness means that different realizations or articulations of one and the same target type must not lead to significantly different LSW results. Measurements on 11 different vehicles of the same type were analysed.



Cross-correlation coefficient between LSW of two different vehicles of the same type as a function of aspect angle

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Objectives of MATRIX 2005

Bring together government, academia and industries to inform each other and exchange ideas on the present status of millimeterwave ATR of relocatable targets

In five different sessions on:

- ATR, based on ISAR analysis
- ATR, based on ISAR and SAR/DBS
- ATR, based on airborne data
- RCS modeling
- ATR, based on data mining / modeling

The participants will define

- Recent achievements
- Present status
- Major gaps and needs
- Future developments

The practical side of Target Recognition

(personal communication LtCol Mark Brandt, USAF)

Situation:

- friendly forces may use the same types of weapons as the enemy due to former WP nations entering NATO (friend-foe identification not widely available or affordable)
- Battlefield can become very complicated (no clear fronts, mixture of friend and foe)
- Asymmetric warfare: enemy may use civilian vehicles instead of hightech weaponry,
- Military installations may be next to innocent infrastructure (hospital, kindergarten, church, marketplace)

ROE require:

- No collateral damage (civilians or innocent property)
- No friendly casualties
- Take into account CNN factor
- Acquire only designated targets:
  - observer on the ground or UAV intelligence
  - man in the loop
  - final decision stays with the pilot (situational awareness, eyeball ID)

The practical side of Target Recognition, cont‘d

Consequences for ATR:

- Completely autonomous weapon systems are applicable in „traditional“ scenarios, but are not likely to be deployed in present day conflicts
- The fighter pilot does not rely 100% on ATR, because P_{cc} values of less than 100% are not acceptable ⇒ challenge for the ATR community to reach P_{fa} =0 !
- There will always be situations where the „Man in the loop“ is indispensable
- Target acquisition is done using multiple sources of information, one important contribution being ATR

We wish to all of us
a successful and enjoyable workshop!

Robust Acquisition of Relocatable Targets using MMW Sensors – SET-069 Historical Look and Purpose

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